REMARKS

A "Substitute Specification & Abstract" is submitted here for the purpose of improving upon the English of the original translation. The "Substitute Specification & Abstract" contains no new matter. In order that the examiner can satisfy himself/herself in this regard, also submitted herewith is a copy of the original English translation showing the changes incorporated into the "Substitute Specification & Abstract".

Also submitted herewith are replacement pages for drawing figures 2, 4, 6 and 7, with reference numbers added to Fig. 2 and Figs. 6 and 7 labeled "Prior Art."

Respectfully submitted,

BACON & THOMAS, PLLC

George A. Loud
Registration No. 25,814

7/3/06
Date

Atty Docket No.: MATS3041
625 Slaters Lane, Fourth Floor
Alexandria, Virginia 22314
703 683-0500

~~DESCRIPTION~~

OIL PUMP AND AUTOMATIC TRANSMISSION INCLUDING THE SAME

BACKGROUND OF THE INVENTION

Technical Field

The present invention relates to oil pumps suitable for supplying working oil to automatic transmissions in vehicles such as automobiles.

~~Art~~ The Related Art

An oil pump of an automatic transmission designed to reduce~~ for a vehicle capable of regulating ~~cavitation erosion is disclosed in Japanese Patent Kokai~~ Application~~ Publication No. 2003-161269. As disclosed therein, the~~According to embodiments, this~~ oil pump includes a cast-iron pump body having a circular hollow formed in a~~portion on an end~~ face thereof; and a light-alloy pump cover ~~connected to the end face~~closing the pump chamber within~~ of~~ the pump body, thereby~~ so as to cover the hollow portion and to~~ forming a gear compartment (pump chamber) therebetween~~; a~~. A drive~~ing~~ gear is supported and driven by a driving shaft journaled ~~in the pump body ~~in the gear compartment~~;~~, and a driven gear disposed in the gear compartment so as to be rotatable eccentric~~ally~~ to the drive~~ing~~ gear and driven by the drive~~ing~~ gear ~~that ~~meshed~~s~~ with the driven gear; an arc-

shaped suction port ~~adjacent to the body~~ and an arc-shaped discharge port are located at~~adjacent to the body formed in~~ the bottom of the ~~hollow portion of the pump body~~ gear compartment in a suction area and a discharge area, respectively~~, of working~~. Working fluid spaces are defined between teeth on~~in~~ the outer circumferential surface of the driven gear and between side walls of the chamber bottom and the cover. Thus~~direction~~, the working fluid spaces are arrayed circumferentially around the pump chamber.~~ formed by the engagement of these gears; and an~~ The arc-shaped suction port is formed in the pump body~~adjacent to the cover~~ and ~~an~~ the arc-shaped discharge port ~~adjacent to the cover~~is formed in the inner side~~end~~ face of the pump cover in the suction area and in the discharge area, respectively, for communication with the rotating~~of the~~ working spaces~~ in the circumferential direction~~.

With the oil pump ~~according to the technology~~ disclosed in Japanese ~~Unexamined Patent Application~~ Patent Kokai Publication No. 2003-161269 (hereinafter simply referred to as the ~~known technology~~"prior art"), cavitation erosion ~~can be regulated as~~ is limited to an expected normal or tolerable level when the rotational speed of the drive ~~ing~~ gear is in a normal range of use (for example, up to 7,000 rpm). However, when the rotational speed of the drive ~~ing~~ gear is higher than that (for example, 7,500 rpm), the

cavitation erosion of the pump cover greatly increases to an unacceptable level. ~~disadvantageously occurs adjacent to the pump cover.~~ This problem will now be described with reference to Figs. 6 and 7.

In the prior art oil pump ~~according to the known technology~~, a notch 5a ~~adjacent to the body is formed~~ is formed in the chamber side face of the pump body, i.e. in the "bottom" of the pump chamber~~a hollow portion of a pump body 1~~ (~~See a~~ Also see ~~a~~ pump body 10 and ~~a hollow portion~~ chamber 11 in Fig. 1), and extends circumferentially from the front end of a discharge port 4a ~~adjacent to~~ formed in the pump body ~~in the circumferential direction~~ to the rear end of a suction port 3a ~~adjacent to the~~ formed in the pump body in the~~ circumferential direction in a~~ suction area ~~of~~ for the working spaces. In addition, a notch 5b ~~adjacent to~~ formed in the pump cover 2, shorter than the notch 5a, ~~adjacent to the body is formed in the inner end face of a pump cover 2, and~~ extends circumferentially from the front end of a discharge port 4b ~~adjacent to~~ formed in the cover to ~~in the circumferential direction to~~ the rear end of a suction port 3b ~~adjacent to~~ formed in the cover. When the~~a~~ drive~~ing~~ gear 6a and ~~a~~ driven gear 6b are rotated in the~~a~~ direction of the~~an~~ arrow during ~~the rotation~~ operation of the oil pump, working spaces R formed between ~~both~~ the teeth of the gears 6a and 6b first~~ly~~ come into communication with

the discharge port 4a ~~adjacent to the body~~ through the notch 5a. ~~adjacent to the body.~~ Since the working spaces R were in communication ~~communicate~~ with the suction ports 3a and 3b until immediately before, the working spaces R are filled with low-pressure working oil entraining ~~including~~ bubbles of a ~~composed of~~ gas of volatiles from the working oil and air released from the working oil. Because~~In contrast~~, the pressure of the working oil in the discharge ports 4a and 4b is ~~high.~~ significantly higher than that at the suction ports, when the working spaces R come into communication ~~communicate~~ with the notch 5a ~~adjacent to the body~~, the high-pressure working oil in the discharge port 4a temporarily~~adjacent to the body temporally~~ flows back from the ~~communicating portion adjacent to the~~ pump body 1 toward the opposing inner ~~end~~ side face of the pump cover 2 ~~at the opposite side~~ and into the working spaces R as indicated by an arrow f. Thus, the bubbles in the working spaces R ~~are crushed,~~ collapse (become smaller) and the impact pressure occurring ~~depending on the crush~~ due to that collapsing causes cavitation erosion at the inner ~~end~~ chamber side face of the pump cover in the vicinity where the bubbles collapse ~~are crushed~~.

When the rotational speed of the oil pump is less than or equal to a predetermined limit, a small number of bubbles are present in the working spaces R, ~~are present. The~~the

pressure of the working oil in the discharge ports 4a and 4b is ~~also~~ not very high, and the rate of inflow ~~rate~~ into the working spaces R is also low. Therefore, the ~~crush~~collapsing of the bubbles mainly occurs adjacent to the bottom of the pump body 1, but ~~the crush~~ is not relatively noticeable. Thus, cavitation erosion ~~adjacent to~~ of the pump body 1 can be prevented ~~due to~~ by forming the pump ~~body 1 composed~~ of a material, such as cast iron, having a high resistance to cavitation erosion. Accordingly, the ~~above-described known~~ prior art technology is effective in preventing cavitation erosion when the rotational speed of the oil pump is less than or equal to the predetermined limit.

However, when~~When~~ the rotational speed of the oil pump~~,~~ ~~however,~~ exceeds the predetermined limit, the pressure in the working spaces R is reduced, ~~Then,~~ the volume of bubbles ~~are~~is increased, and the bubbles ~~easily~~ accumulate~~d~~ adjacent ~~to~~ the inner circumference due to the increased centrifugal force. Moreover, the pressure of the working oil in the discharge ports 4a and 4b is increased, and the rate of inflow ~~rate~~ into the working spaces R is also increased. Accordingly, the position where the ~~crush~~ collapsing of the bubbles occurs is shifted ~~adjacent~~ to the inner ~~end~~ side face of the pump cover 2, and more bubbles collapse ~~are crushed~~. Since the pump cover 2 is composed of

a material, such as aluminum, having low resistance to cavitation erosion, cavitation erosion occurs at the~~-a~~ position indicated by the ~~a~~ symbol E1 at ~~in~~the inner ~~end~~ side face of the pump cover 2, as shown in Fig. 7(b). Thus, gaps are formed between the pump gears 6a and 6b, and pump efficiency is reduced due to leaking of the working oil. It is believed that cavitation erosion occurs ~~adjacent to~~ at the pump cover 2 by the above-described ~~action~~ mechanism when the rotational speed of the oil pump exceeds the predetermined limit.

To solve ~~this~~ the above-described problem, ~~a possible solution is to provide a~~ theoretically it would be possible to form the pump cover 2 composed of a metallic material having high resistance to cavitation erosion~~. In this case~~, e.g. aluminum with, for example, T6 heat treatment ~~to~~ for increaseing the surface strength or high-silicon aluminum alloy. However, such materials do ~~does~~ not always solve the problem ~~since many~~ because of the large volume of bubbles ~~generated~~ in the working spaces R ~~by cavitation~~ which are collapsed (crushed), and therefore, a material such as cast iron having high resistance to cavitation erosion is required. In such a case, the weight of the oil pump is disadvantageously increased since both the pump body 1 and the pump cover 2 are composed of cast iron. When such ~~an~~ a heavy oil pump is installed in an ~~automotive~~ automatic

transmission ~~for a vehicle~~, the pump body or the pump cover of the oil pump cannot be integrated with the transmission housing which is composed of a light alloy, resulting in a complicated structure.

Disclosure of Invention

To solve the above-described problem, ~~the main object of~~ the present invention ~~is to~~ provides an oil pump capable of ~~surely regulating the~~ reducing cavitation erosion during high-speed rotation of the ~~driving~~ gears even when the pump cover is composed of a conventional light alloy.

According to the present invention, the above-described object can be achieved by an oil pump including a pump body having a hollow ~~portion on an end~~ recess in a side face thereof; a pump cover having an~~, the~~ inner side ~~end~~ face of the pump cover connected to the end face ~~of the pump body so as to cover~~ closing the hollow ~~portion and~~ recess to form a gear compartment~~ therebetween~~; a drive ~~ing~~ gear driven by a drive ~~ing~~ shaft and rotably supported in the gear compartment; a rotatable driven gear disposed in the gear compartment and driven by the drive ~~ing~~ gear ~~that meshes with the driven gear~~; a discharge port ~~adjacent to~~ formed in the pump body and a discharge port ~~adjacent to~~ formed in the pump cover, the discharge ports defining, within the gear compartment, ~~formed in the bottom of the hollow portion of~~

~~the pump body and the inner end face of the pump cover, respectively, in~~ a discharge area ~~of~~for working spaces formed by the engagement of teeth of the drive ~~ing~~ gear ~~and~~ with the teeth the driven gear; a notch ~~adjacent to~~ formed in the pump body and extending from the front end of the discharge port ~~adjacent to the body~~ to the rear end of the discharge area ~~of the working spaces at the bottom of the hollow portion of the pump body~~; and a notch ~~adjacent to~~ formed in the cover and extending from the front end of the discharge port ~~adjacent to the cover~~ to the rear end of the discharge area. ~~of the working spaces at the inner end face of the pump cover,~~ O~~o~~ne of the pump body and the pump cover ~~composed~~ is formed of cast iron and the other ~~composed~~ is formed of a light alloy~~,~~. ~~characterized in that t~~ The length of the notch formed in the pump body or the pump cover ~~composed~~ formed of the light alloy is longer than that of the notch formed in the pump body or the pump cover composed of the cast iron. ~~, and~~ B~~b~~ubbles generated within the~~in working~~ oil in the working spaces during ~~the~~ high-speed rotation of the drive ~~ing~~ gear are ~~crushed~~ reduced by the high-pressure working oil flowing back ~~to~~ into the working spaces through the longer notch ~~adjacent to the inner surface of~~ in the pump body or the pump cover ~~composed~~ formed of the cast iron. ~~facing the working spaces~~.

~~According to the oil pump of the present invention,~~

~~it~~It is preferred ~~able~~ that the driven gear be a rotatable internal gear having ~~the~~ its outer circumference supported by the inner circumferen~~ce~~tial surface of the gear compartment; that the drive ~~ing~~ gear be an external gear meshing with the driven gear; that the discharge port ~~adjacent to~~ in the pump body and the discharge port ~~adjacent to~~ in the pump cover ~~be~~ each be arc-shaped; and that the notch ~~adjacent to~~ in the pump body and the notch ~~adjacent to~~ in the pump cover extend circumferentially from the front ends of the discharge port ~~adjacent to~~ in the pump body and the discharge port ~~adjacent to~~ in the pump cover, respectively, ~~in the circumference direction~~ to the rear end of the discharge area ~~of the working spaces~~.

~~According to the oil pump of the present invention, it~~ It is further preferred~~able~~ that the notch formed in the pump body or the pump cover composed of the light alloy have an approximately triangular shape and a width decreasing from the front end of the discharge port ~~adjacent to~~ in the pump cover toward the rear end of the discharge area ~~of the working spaces~~.

Moreover, ~~according to the oil pump of the present invention,~~ it is preferred ~~able~~ that the notch formed in the pump body or the pump cover composed of the light alloy have an inclined bottom so ~~as to reduce the~~ that its depth decreases from the front end of the discharge port ~~adjacent~~

~~to~~ in the cover toward the rear end of the discharge area~~ of the working spaces~~.

Furthermore, the present invention provides an automatic transmission ~~according to the present invention is characterized in that the~~ having, as a supply source of ~~the~~ hydraulic pressure, ~~is~~ the oil pump according to the present invention, ~~and~~ wherein the pump body or the pump cover composed of the light alloy is integrated with the ~~a~~ housing of the automatic transmission.

Brief Description of the Drawings

Fig. 1 is a cross-sectional view of an oil pump according to an embodiment of the present invention;

Fig. 2 is a cross-sectional view taken along line 2 - 2 in Fig. 1;

Fig. 3 is a cross-sectional view taken along line 3 - 3 in Fig. 2;

Figs. 4(a) and 4(b) illustrate the arrangement of ports and notches ~~according to~~ in the embodiment shown in Fig. 1, Fig. 4(a) illustrates part of the bottom of a hollow portion of a pump body, and Fig. 4(b) illustrates part of an inner end face of a pump cover;

Fig. 5 ~~illustrates~~ is a graph of the relationship between rotational angles of pump gears and open cross-sectional areas between working spaces and discharge ports

~~according to~~ in the embodiment shown in Fig. 1;

Fig. 6 is a cross-sectional view, corresponding to Fig. 2, of ~~an~~ a prior art oil pump; and ~~corresponding to Fig. 2 according to the known technology; and~~

Figs. 7(a) and 7(b) are partial views, corresponding to Figs. 4(a) and 4(b), of the prior art oil pump of Fig. 6 ~~corresponding to Figs. 4(a) and 4(b)~~ ~~according to the known technology~~.

DESCRIPTION OF PREFERRED EMBODIMENTS

~~Best Mode for Carrying Out the Invention~~

A preferred embodiment of a~~A~~n oil pump according to ~~an embodiment of~~ the present invention will now be described with reference to Figs. 1 to 5. The oil pump ~~according to the~~ of this preferred embodiment ~~supplies~~ is suitable for supplying working ~~oil~~ fluid to an automatic transmission for a vehicle such as an automobile~~,~~ and includes: a housing H consisting of a pump body 10 and a pump cover 15 connected to each other, and pump gears consisting of a driving gear 30 and a driven gear 31 ~~accommodated~~ rotatably mounted in the housing H ~~so as to be rotatable~~. The pump cover 15 is integrated with a housing of an automotive automatic transmission ~~for an automobile~~.

The pump body 10 is composed of a metallic material such as cast iron having high resistance to cavitation

erosion. ~~With reference to~~ As shown in Fig. 1, a narrow circular ~~hollow portion~~ chamber 11, which ~~with a predetermined shallow depth~~ accommodates ~~ing~~ the rotatable pump gears 30 and 31, ~~so as to be rotatable~~ is formed in a flat side face of the pump body 10~~,~~. ~~And a~~ A center hole 12 passes ~~ing~~ through the pump body 10, opens into ~~is formed at the bottom of~~ the ~~hollow portion~~ chamber (gear compartment) 11 ~~so as to be decentered~~ and is axially offset from the center of the hollow portion 11 by a distance equal to ~~that~~ an axial offset between the pump gears 30 and 31. The pump cover 15 is composed of a light alloy such as aluminum having less resistance to cavitation erosion ~~lower~~ than ~~that~~ the cast iron of the pump body 10. The pump cover 15 is bolted to the pump body 10 ~~such that~~ with a flat side face thereof hermetically covering (closing)~~covers~~ the ~~hollow portion~~ chamber 11,~~. T~~ thus, forming a gear compartment G, accommodating the pair of pump gears 30 and 31, ~~is formed~~ between the pump body 10 and the pump cover 15. A tubular stator shaft 17 is pressed into a center hole 16 formed in the pump cover 15 coaxial ~~ly to~~ with the center hole 12 of the pump body 10, and passes through the pump body 10 ~~so as to be remote from~~ with an annular space between it and the peripheral wall defining the center hole 12~~ with a space~~. A tubular drive ~~ing~~ shaft 13 is fitted into the annular~~ a~~ space between the stator shaft 17 and the center hole 12,

and is rotatably supported by a ~~rotatable bearing~~ bushing 12a fixed to the ~~inner face of~~ peripheral wall defining the center hole 12. ~~A~~The annular space between the drive~~ing~~ shaft 13 and the pump body 10 is sealed by an oil seal 14.

The ~~external~~ driving gear 30 and the ~~internal~~ driven gear 31, having one more ~~additional~~ tooth than the driving gear 30, have the same thickness~~,~~ and ~~have~~ trochoidal teeth meshed with each other. Both ~~the~~ side faces of these gears ~~are remote from~~ are located sufficiently close to both the inner side faces of the gear compartment G to~~formed by the pump body 10 and the pump cover 15 with sufficiently small gaps such that working oil~~ substantially prevent ~~does not~~ leakage therebetween and ~~from the gaps, and~~ are slidable and rotatable relative to the inner side faces of the gear compartment G. The driving gear 30 ~~is supported by fitting the~~ has its inner circumference ~~thereof~~ fixed to the outer circumference of an end of the drive ~~ing~~ shaft 13~~, and~~ by a pair of keys 30a protruding into ~~from the inner circumference is caught by~~ keyways formed in the end of the driving shaft 13 such that the driving gear 30 ~~is rotatable~~ can be rotatably driven by the drive shaft 13. The outer circumference of the driven gear 31 is rotatably supported by the inner circumferen~~ce~~tial surface of the hollow ~~portion~~ chamber 11 ~~so as to be rotatable~~.

As ~~mainly~~ shown in Fig. 2, a ~~large number~~ plurality of

working spaces R are formed between ~~each tooth~~ the teeth of the pump gears 30 and 31 ~~accommodated in the gear compartment G and~~ which are in mesh ~~ing with each other~~. ~~While~~ As the pump gears 30 and 31 are rotated, the working spaces R move along an annular space formed between the root circles of the pump gears 30 and 31, and each volume of the working spaces R alternately increases ~~is increased~~ and decrease~~d~~s. A suction area where the volumes of the working spaces R ~~are~~ gradually increase~~d~~ during the rotation of the pump gears 30 and 31 is formed [[in]] through a range of 180° from a contact position of pitch lines of the pump gears 30 and 31 in the rotational direction of the pump gears 30 and 31, and a discharge area where the volumes of the working spaces R ~~are~~ gradually decrease~~d~~ during the rotation of the pump gears 30 and 31, is formed in a range of 180° from the contact position of the pitch lines of the pump gears 30 and 31 in the direction opposite ~~direction to~~ the rotational direction.

As shown in Figs. 1 and 2, a suction port 20a ~~adjacent to~~ extending through the pump body 10 and a suction port 20b ~~adjacent to~~ extending through the pump cover are in opposition to ~~opposing~~ each other and are ~~formed~~ in communication with the bottom of the ~~hollow portion~~ chamber 11 [[of]] in the pump body 10 ~~and in the inner end face of the pump cover 15 opposing the bottom of the hollow portion~~

~~11, respectively, and range in considerable areas corresponding to the suction area except for both ends~~. The openings~~Openings~~ of the suction ports 20a and 20b ~~are~~ have the same arc-shape, and their ~~shapes and the~~ areas are equal. The radially inner ~~ends~~ edges 40a and 40b and the radially outer ~~ends~~ edges a41a and 41b of the suction ports 20a and 20b correspond to (are axially aligned with) the root circles of the pump gears 30 and 31, respectively. The suction ports 20a and 20b communicate with suction channels 21 formed in the pump body 10 and the pump cover 15 and introduce~~introducing~~ the working oil from a reservoir (not shown).

M~~oreover~~ As seen in Fig. 3, a discharge port 25a ~~adjacent~~ formed in to the pump body 10 and a discharge port 25b ~~adjacent to~~ formed in the cover ~~opposing~~ are arranged in opposition to each other ~~are formed~~ in the bottom of the ~~hollow portion~~ chamber 11 ~~of the pump body 10 and in the inner end face of the pump cover 15 opposing the bottom of the hollow portion 11, respectively,~~ and ~~range in~~ extend over considerable ~~areas corresponding to~~ portions of the discharge area ~~except for~~ short of both ends of the discharge area. Openings of the discharge ports 25a and 25b are arc-shaped, and ~~the shapes and the~~ have equal areas~~-are equal~~. The radially inner ~~ends~~ edges 42a and 42b and the radially outer ~~ends~~ edges 41a and 41b of the discharge ports

25a and 25b correspond to (are axially aligned with) the root circles of the pump gears 30 and 31, respectively. A sloped surface 25a1 having a depth decreasing toward the front end (in the rotational direction) where the discharge port 25a first comes into communication with the moving working spaces R ~~starts~~ is formed in part of the bottom of the discharge port 25a ~~adjacent to the body~~. The discharge port 25a ~~adjacent to~~ formed in the pump body 10 communicates with a discharge channel 27 formed in the pump body 10 and the pump cover 15. ~~and supplying the working oil to a destination. On the other hand, the~~The discharge port 25b ~~adjacent to~~ formed in the pump cover 15 is made shallower than the discharge port 25a ~~adjacent to~~ formed in the pump body ~~so as to avoid~~ 10 and is isolated from a fluid channel (not shown) formed in the pump cover 15~~,~~ and ~~does not communicate with~~ from the discharge channel 27.

As shown in Figs. 1 to 4, a notch 26a is formed in ~~adjacent to~~ the pump body 10 in communication ~~ing~~ with the discharge port 25a ~~adjacent to the body~~ and a notch 26b ~~adjacent to~~ is formed in the cover 15 in communication ~~ing~~ with the discharge port 25b ~~adjacent to the cover are formed in the bottom of the hollow portion 11 of the pump body 10 and in the inner end face of the pump cover 15 opposing the bottom of the hollow portion 11, respectively~~. The notches 26a and 26b extend from the front, in the direction of

rotation, ends of the discharge ports 25a and 25b ~~in the rotational direction along the~~ circumferentially direction to the rear ends of the suction ports 20a and 20b ~~in the rotational direction along the circumferential direction~~, respectively. The notch 26b ~~adjacent to~~ formed in the cover 15 is longer than the notch 26a ~~adjacent to~~ formed in the body 10. The length of the longer notch 26b ~~adjacent to the cover~~ is a fraction (for example, 1/4) of the distance between the rear direction of rotation in the ends of the suction ports 20a and 20b ~~in the rotational direction~~ and the front ends of the discharge ports 25a and 25b ~~in the rotational direction~~. The length of the shorter notch 26a ~~adjacent to the body~~ is approximately one half to one quarter ~~of~~ that of the notch 26b ~~adjacent to the cover~~. In this embodiment, as shown in Figs. 2 to 4, the notch 26b ~~adjacent to~~ in the cover has an approximately triangular shape and a width decreasing from the front end of the discharge port 25b ~~adjacent to the cover in the rotational direction~~ toward the rear end of the suction port 20b ~~adjacent to the cover in the rotational direction~~ when viewed from side of the pump body 10. Also, the bottom of the notch 26b ~~adjacent to~~ in the cover is inclined so as to reduce its ~~the~~ depth from the front end of the discharge port 25b ~~adjacent to the cover in the rotational direction~~ toward the rear end of the suction port 20b ~~adjacent to the~~

~~cover in the rotational direction~~.

In Fig. 2, during the operation of the oil pump according to this embodiment, the pump gears 30 and 31 are rotated by the driving shaft 13 in the ~~a~~ direction of the ~~a~~ arrow, i.e. counterclockwise, and the working spaces R are rotated in the same direction while the volumes thereof ~~are changed~~change. In Fig. 3, the pump gears 30 and 31 and the working spaces R are moved leftward as indicated by the ~~an~~ arrow. As a result, the working oil in the reservoir passes through the suction channels 21~~, is sucked from both~~ and through the suction ports 20a and 20b into the working spaces R in the suction area, and is discharged from the working spaces R in the discharge area, through ~~to~~ the discharge ports 25a and 25b, and ~~is supplied to the destination~~ through the discharge channel 27.

Since the pressure of the working oil in the suction area is negative, the working oil ~~sucked~~ entering from the suction ports 20a and 20b into the working spaces R includes entrained air bubbles. The working spaces R sucking the working oil move ~~according to~~ with the rotation of the pump gears 30 and 31, and are ~~shut~~ closed in direction of rotation ~~the space~~ between the rear ends of the suction ports 20a and 20b ~~in the rotational direction~~ and the front ends of the discharge ports 25a and 25b ~~in the rotational direction and between the bottom of the hollow portion 11~~

~~and the inner end face of the pump cover 15~~. As shown in Fig. 3, when the tips of the working spaces R ~~further move and pass~~ rotate past a first release point P1 (See Fig. 5) ~~being~~ at the tip (front end) of the notch 26b ~~adjacent to~~ in the pump cover 15, the working spaces R communicate with the discharge port 25b ~~adjacent to~~ in the cover through the ~~tip of the~~ notch 26b ~~adjacent to the cover~~. Furthermore, when the tips of the working spaces R ~~pass~~ rotate past a second release point P2 ~~being~~ at the tip (front end) of the notch 26a ~~adjacent to~~ in the pump body 10, the working spaces R communicate with the discharge port 25a ~~adjacent to~~ in the pump body 10 through the ~~tip of the~~ front end of notch 26a, ~~adjacent to the body~~ in addition to the communication through the notch 26b ~~adjacent to the cover~~. Finally, when the tips of the working spaces R ~~pass~~ ~~rotate past~~ a third release point P3 ~~being~~ at the front ends of the discharge ports 25a and 25b ~~in the rotational direction~~, the working spaces R come into direct~~-directly communicate~~ communication with the discharge ports 25a and 25b. Accordingly, open cross-sectional areas between the working spaces R and the discharge ports 25a and 25b that are filled with the working oil ~~shut~~, trapped in the space between the bottom face (wall) of the ~~hollow portion~~ chamber 11 and the inner end face of the pump cover 15 and ~~including~~ containing bubbles due to the low pressure, are acceleratingly and continuously

increased, ~~depending on~~ in accordance with the rotational angles of the pump gears 30 and 31 as indicated by the solid line shown in Fig. 5.

As shown in Fig. 3, when the tips of the working spaces R that ~~were shut~~ are closed in the space between the bottom of the hollow portion 11 and the inner end face of the pump cover 15 ~~pass~~ rotate past the first release point P1 so as to communicate with the discharge port 25b ~~adjacent to the cover~~ through the tip (front end) of the notch 26b ~~adjacent to the cover~~, the high-pressure working oil in the discharge port 25b temporarily ~~adjacent to the cover temporarily~~ flows back ~~from the communicating portion adjacent to the pump cover 15~~ into the working spaces R as indicated by an arrow F. Thus, the pressure in the working spaces R is increased, and the bubbles therein are crushed. ~~While~~ When the pump gears 30 and 31 are rotated ~~after~~ beyond the point communication starts, the opening area of the longer notch 26b ~~adjacent to~~ in the cover is increased relative to the working spaces R. Accordingly ~~to this~~, ~~an~~ the inflow rate of the working oil from the discharge port 25b adjacent to the cover into the working spaces R is reduced, and therefore, fewer bubbles in the working spaces R are crushed. When the shorter notch 26a ~~adjacent to the body~~ is brought into communication ~~communicates~~ with the working spaces R, the inflow rate into the working spaces R is further reduced,

and still fewer bubbles in the working spaces R are crushed.

When the rotational speed of the oil pump is less than or equal to a predetermined limit (for example 7,000 rpm), a small number of bubbles are present in the working spaces R ~~are present~~, and the pressure of the working oil in the discharge ports 25a and 25b ~~are~~ is also not very high. In addition, the ~~inflow~~ rate of inflow of the working fluid ~~that flows~~ from the notch 26b ~~adjacent to the cover~~ toward the bottom of the ~~hollow portion~~ side wall of the chamber 11 of the pump body 10 ~~at the opposite side~~ into the working spaces R, as indicated by the arrow F in ~~the state shown in~~ Fig. 3, is low. Thus, the ~~crush~~ reduction of the bubbles ~~mainly~~ occurs mainly adjacent~~ to~~ the inner ~~end~~ side face of the pump cover 15, but the ~~crush~~ reduction is not relatively noticeable. Therefore, if the pump cover 15 is composed of a material such as aluminum having low resistance to cavitation erosion, the small amount of cavitation erosion that occurs at ~~in~~ the inner ~~end~~ side face is substantially insignificant. As described above, ~~while~~ as the pump gears 30 and 31 ~~are~~ rotate~~d after~~ further, beyond the point where communication starts, the inflow rate of the working oil from the discharge port 25b ~~adjacent to the cover~~ into the working spaces R is reduced, and therefore, the cavitation erosion that occurs [[in]] at the inner ~~end~~ side face of the pump cover 15 is further ~~regulated~~ reduced.

When the rotational speed of the oil pump exceeds the predetermined limit (for example 7,500 rpm), the pressure in the working spaces R is reduced. Then, the volume of bubbles ~~are~~ is increased, and ~~are~~ the bubbles accumulate ~~accumulated~~ adjacent ~~to~~ the inner circumference of the working spaces R due to the centrifugal force. Moreover, the pressure of the working oil in the discharge ports 25a and 25b ~~are increased~~increases, and the rate of inflow ~~rate~~ of the working fluid that flows toward the bottom of the ~~hollow portion~~ chamber 11 of the pump body 10, into the working spaces R as indicated by the arrow F, is also increased. Accordingly, the position where the ~~crush of the~~ bubbles are collapsed (reduced in size) occurs is shifted toward the area adjacent ~~to the~~ bottom of the ~~hollow~~ chamber portion 11 (pump body side surface) in the working spaces R, and also, more bubbles are ~~crushed~~ thereby collapsed. However, the pump body 10 is composed of a material such as cast iron having high resistance to cavitation erosion, so that the collapsing bubbles are shifted to an area highly resistant to the cavitation erosion ~~does not occur~~ at the bottom of the ~~hollow portion~~ chamber 11 which is formed in [[of]] the pump body 10. In addition, as described above, ~~while~~ as the pump gears 30 and 31 ~~are~~ rotate ~~d after the~~ beyond the point where communication starts, the ~~opening~~ area of the opening of the notch 26b ~~adjacent to the cover~~

is increased, the shorter notch 26a ~~adjacent to the body~~ is brought into communication~~communicates~~ with the working spaces R, and therefore, the position where the ~~crush of the~~ bubbles are collapsed ~~occurs~~ is shifted toward an area adjacent~~ to~~ the inner ~~end~~ side face of the pump cover 15. However, since the rate of inflow ~~rate~~ of the working oil from the notches 26a and 26b into the working spaces R is reduced, the cavitation erosion is ~~regulated~~ also reduced.

In the above-described embodiment, the notch 26b ~~adjacent to~~ in the cover 15 has an approximately triangular shape and a width decreasing from the front end of the discharge port 25b ~~adjacent to the cover in the rotational direction~~ toward the suction port 20b ~~adjacent to the cover~~, and also, the bottom of the notch 26b ~~adjacent to the cover~~ is inclined so as to gradually reduce ~~the~~ its depth. With this structure, the ~~opening~~ area of the opening of the notch 26b ~~adjacent to the cover~~ relative to the working spaces R is immediately increased in response to the rotation of the pump gears 30 and 31, the rate of inflow ~~rate~~ of the working oil from the notch 26b ~~adjacent to the cover~~ into the working spaces R is immediately reduced, and therefore, the ~~crush~~ collapsing (reduction) of the bubbles is also immediately reduced. Accordingly, when the rotational speed of the oil pump is less than or equal to a predetermined limit, the small amount of cavitation erosion that occurs~~ in~~

the inner end face of the pump cover 15 is further reduced. However, the present invention is not limited to ~~that~~ the embodiments described above. For example, the~~The~~ notch 26b ~~adjacent to~~ in the cover 15 may have a predetermined width and length, as in the case of [[a]] notch 5a ~~adjacent to the body according to the known technology~~ of the prior art shown in Figs. 6 and 7. ~~In varying degrees, the cavitation erosion can be regulated as described above, and the effect is sufficient in some cases.~~

Furthermore, in the above-described embodiment, the driven gear 31 is a rotatable internal gear having ~~the~~ its outer ~~circumference~~circumferential surface supported by the inner circumferential surface~~circumference~~ of the gear compartment G, and the drive ~~ing~~ gear 30 is an external gear that meshes with the driven gear 31. With this structure, the driving gear 30 can be accommodated in the driven gear 31 so as to reduce the volume of the pump gears 30 and 31, and a small oil pump can be produced. However, the present invention is not limited to that described above in that~~,~~ ~~and~~ both the pump gears may be of an external type, ~~. I~~ in ~~this~~ which case, the ~~hollow portion~~ may have a shape consisting of two circles overlapped at ~~the~~their rims.

The oil pump according to the above-described embodiment supplies working oil to an automatic transmission for a vehicle. Since the pump cover 15 is composed of a

light alloy having low resistance to ~~the~~ cavitation erosion, the pump cover 15 can be integrated with the transmission housing also composed of ~~the~~ a light alloy such as aluminum. As a result, the structure of the automatic transmission with the oil pump can be simplified. However, here also, the application of the oil pump according to the present invention is not limited to that described above. The oil pump ~~is available~~ may be used as a supply source of ~~the~~ working oil ~~used~~ in various other devices, such as infinitely variable transmissions for vehicles. Also, the pump body may be composed of aluminum or the like having low resistance to ~~the~~ cavitation erosion, and the pump cover may be composed of cast iron or the like having high resistance to ~~the~~ cavitation erosion, depending on the applications and the circumstances. In this latter case, the length of the ~~a~~ notch formed in the pump body composed of aluminum or the like ~~may~~ would be made larger than that of the ~~a~~ notch formed in the pump cover composed of cast iron or the like.

ABSTRACT

~~In this~~ An oil pump includes, a pump cover covering a recess in a side ~~15 is connected to an end face of a pump body 10 having a hollow portion 11 on the end~~ face of a pump body~~ so as~~ to form a gear compartment therebetween. A drive~~ing~~ gear ~~30 driven by a driving shaft 13~~ and a ~~rotatable~~ rotatably driven gear ~~31 meshing with the driving gear 30~~ are ~~disposed~~ meshed and mounted in the gear compartment~~ G~~. ~~At positions corresponding to a discharge area of working~~ Working spaces R are formed by the engagement of the gear~~these gears 30 and 31, a~~ teeth. ~~discharge port~~Discharge ports ~~25a adjacent to~~ are formed in both the pump body and ~~a~~ ~~discharge port 25b adjacent to~~ the pump cover ~~are formed in the bottom of the hollow portion 11 of the pump body 10 and in the inner end face of the pump cover 15, respectively~~ in communication with the gear compartment. A notch ~~26a adjacent to the body~~ is formed ~~in the pump body~~ at the bottom of the ~~hollow portion 11 of the pump body 10~~ gear compartment~~,~~ and extends from the front end of ~~the~~ a discharge port ~~25a adjacent to~~ in the pump body to the rear end of the discharge area for~~of~~ the working spaces~~ R~~. Another~~A~~ notch ~~26b adjacent to the cover~~ is formed in the inner ~~end~~ side face of the pump cover~~ 15~~, and extends from the front end of the discharge port ~~25b~~ in ~~adjacent to~~ the

cover to the rear end of the discharge area. ~~of the working spaces R. One of the pump body 10 and the pump cover 15 is composed of cast iron, and the other is composed of a light alloy. The length of the notch 26a or 26b formed in the pump body 10 or the pump cover 15 composed of the light alloy is made longer than that formed in the pump body 10 or the pump cover 15 composed of the cast iron such that bubbles generated in working oil in the working spaces R during the high-speed rotation of the driving gear 30 are crushed by the high pressure working oil flowing back to the working spaces R through the longer notch adjacent to the inner surface of the pump body 10 or the pump cover 15 composed of the cast iron facing the working spaces R. In this oil pump, the driven gear 31 is preferably a rotatable internal gear having the outer circumference supported by the inner circumference of the gear compartment G, and the driving gear 30 is preferably an external gear meshing with the driven gear 31. Moreover, the notch 26a or 26b formed in the pump body 10 or the pump cover 15 composed of the light alloy preferably has an approximately triangular shape and a width decreasing toward a suction port 20b adjacent to the cover, and preferably has an inclined bottom so as to reduce the depth.~~